Electronic Version
Stylesheet Version v1.1.1

Claims

[c1] 1. A battery separator comprising a microporous membrane having a thickness of 5 to 175μm, a porosity of between 30% and 95%, and an air permeability of between 1sec/10cc and 100 sec/10cc, said microporous membrane comprised of a ultra high molecular weight polyolefin having a minimum average molecular weight of $1x10^6$, and a TiO_2 particulate filler with an average particle size diameter of between 0.001μm and 10 μm.

[c2] 2. The battery separator in accordance with claim 1, wherein said microporous membrane is comprised of between 4% and 95% ultra high molecular weight polyethylene and between 1 wt % and 96 wt % of TiO_2.

[c3] 3.The battery separator in accordance with claims 1 or 2, and further having a shutdown temperature of 135°C plus or minus 10°C.

[c4] 4.The battery separator in accordance with claims 1 or 2, and further having melt integrity of 165°C or more.

[c5] 5.The battery separator in accordance with claims 1 or 2, and further a puncture resistance of more than 300 grams/25μm.

[c6] 6.The battery separator in accordance with claims 1 or 2, and further having a thermal shrinkage of 10% or less both in the machine and transverse directions.

[c7] 7.The battery separator in accordance with claims 1 or 2, wherein said separator is used in a non-aqueous electrolyte battery.

[c8] 8.The battery separator in accordance with claims 1 or 2, wherein said separator"s surface is treated with a substance chosen from the group consisting of (a) a wetting agent and (b) a hydrophilic grafting agent, for use in an aqueous electrolyte battery.

[c9] 9.The battery separator in accordance with claims 1 or 2, wherein said separator has an average pore diameter of between 0.01μm and 1μm.

[c10] 10.A method for producing the battery separator of claim 1 which comprises the steps of
(a) preparing a dry blend of between 4wt % and 99 wt % of an ultra high molecular weight polyethylene having an average molecular weight of $1x10^6$ or more and between 1% and 96% of a TiO_2 particulate filler with average particle size diameter of between 0.001μm and 10μm;
(b) mixing the dry blend with between 40wt % and 90 wt % plasticizer in an extruder, forming a solution;

(c) extruding the solution through a film die, creating an extruded film;
(d) calendering the extruded film at between 30°C and 120°C;
(e) removing the plasticizer by the extraction method;
(f) uni-axially or bi-axially stretching the film at between 110°C and 130°C at a stretching ratio of 2 or more in the transverse direction, the machine direction, or both; and
(g) heat-setting the film at between 110°C and 130°C.

[c11] 11.A microporous battery separator having a thickness of between 5μm and 175μm, a porosity of between 30wt % and 95 wt %, and an air permeability of between 5 sec/10cc and 200 sec/10cc, said microporous membrane comprising a ultra high molecular weight polyolefin having a minimum average molecular weight of $1x10^6$, a low molecular weight polyethylene with an average molecular weight of between 700 and 4500, and a TiO_2 particulate filler with an average particle size diameter of 0.001 to 10 μm.

[c12] 12.A battery separator in accordance with claim 11, wherein said microporous membrane is comprised of between 1wt % and 90 wt % ultra high molecular weight polyethylene, 1wt % and 90 wt % low molecular weight polyethylene and 1wt % and 90 wt % TiO_2.

[c13] 13.A battery separator in accordance with claim 11 or 12 having shutdown temperatures of between 95°C and 135°C.

[c14] 14.A battery separator in accordance with claim 11 or 12 having melt integrity of 165°C or more.

[c15] 15.A battery separator in accordance with claim 11 or 12 having a puncture resistance of more than 300 grams/ 25μm.

[c16] 16.A battery separator in accordance with claim 11 or 12 wherein said separator is used in a non-aqueous electrolyte battery.

[c17] 17.A battery separator in accordance with claim 11 or 12 wherein said separator"s surface is treated with a substance chosen from the group consisting of (a) a wetting agent and (b) a hydrophilic grafting agent, for use in an aqueous electrolyte battery.

[c18] 18.A method for producing a battery separator which comprises the steps of:
(a) preparing a dry blend of between 1wt % and 90 wt % of an ultra high molecular weight polyethylene having an average molecular weight of $1x10^6$ or more, between 1wt % and 90 wt % low molecular weight polyethylene with average molecular weight of between 700 and

4500, and between 1 wt % and 96 wt % of a TiO_2 particulate filler with an average particle size diameter of 0.2 μm or less;
(b) mixing the dry blend with between 40wt % and 90 wt % plasticizer in an extruder,
(c) extruding the solution through a sheet die producing an extruded film thereby;
(d) calendering the extruded film at between 70°C and 120°C;
(e) uni-axially or bi-axially stretching the film at between 80°C and 120°C at stretching ratio of 2 or more in the transverse direction, the machine direction, or both;
(f) removing the plasticizer by an extraction method; and
(g) heat-setting the film at between 70°C and 100°C.

[c19] 19.A battery which comprises the battery separator in accordance with claim 1.

[c20] 20.A battery which comprises the battery separator in accordance with claim 11.

[c21] 21.A microporous filter which comprises the microporous membrane in accordance with claim 1.

[c22] 22.A microporous filter which comprises the microporous membrane in accordance with claim 11.